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Automatic Fire Protection Systems for Large Haulage Vehicles

Prototype Development and In-Mine Testing

UNITED STATES DEPARTMENT OF THE INTERIOR

Information Circular 8683

Automatic Fire Protection Systems for Large Haulage Vehicles

Prototype Development and In-Mine Testing

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UNITED STATES DEPARTMENT OF THE INTERIOR
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AUTOMATIC FIRE PROTECTION SYSTEMS FOR LARGE HAULAGE VEHICLES

Prototype Development and In-Mine Testing

by

Guy A. Johnson[1] and David R. Forshey[2]

ABSTRACT

The Bureau of Mines, through research and development contracts with the FMC Corp., has developed and tested two automatic fire sensing and suppression systems for large haulage vehicles. This work was undertaken to enhance driver safety, to lessen substantial property damage from fires on large trucks, and to increase the vehicle operator's productivity.

One automatic truck fire protection system protects both the engine compartment and brake grid areas, while the second system is used in the engine compartment and fuel tank area. Both systems have redundant fire-sensing capabilities and manual override controls. Upon sensing flames and/or heat, the systems suppress the fire with pressurized, B-C class dry chemical. Both fire protection systems are flexible in design and can be modified for use on other mobile mining equipment. Prototypes of both systems have been subjected to long-term, in-mine validation testing and actual fire tests on 100-ton-capacity trucks at the Pima mine near Tucson, Ariz., and the Erie mine at Hoyt Lakes, Minn. During the 4-month endurance test of the first system at Pima, an accidental flash fire occurred in the test truck while it was working in the pit. The system successfully sensed and automatically extinguished the fire with no injury to the driver and little damage to the truck.

INTRODUCTION

As mine haulage vehicles become larger, the danger to operators during fire emergencies is increased because the cabs are farther from the ground. Also, access ladders are usually located next to engine compartments where most vehicle fires occur. Frequently drivers are not immediately aware of fires and escape is difficult owing to the position of cabs on vehicles. This danger was illustrated, unfortunately, in January of 1973 when a truck driver working in an iron ore mine in Upper Michigan was seriously hurt when he was forced to jump from his truck during a flash fire in the engine compartment. The truck was a 75-ton-capacity model (which is of only moderate

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TYPICAL FACTORS CONSIDERED IN DEVELOPING SYSTEMS

FIRE

- CLASS
- SIZE
- SPEED OF PROPAGATION
- COMPONENT

SENSOR

- OPTICAL
- THERMAL
- GAS/SMOKE
- PRESSURE

EXTINGUISHING AGENT

- DRY POWDER
- FOAM
- WATER
- GAS

CONTROL SYSTEM

- MANUAL/SEMIAUTOMATIC/AUTOMATIC
- VISUAL/AUDIBLE WARNING
- LOGIC

COST

- DEVELOPMENT
- PRODUCTION

FIGURE 1. - Typical design criteria factors.

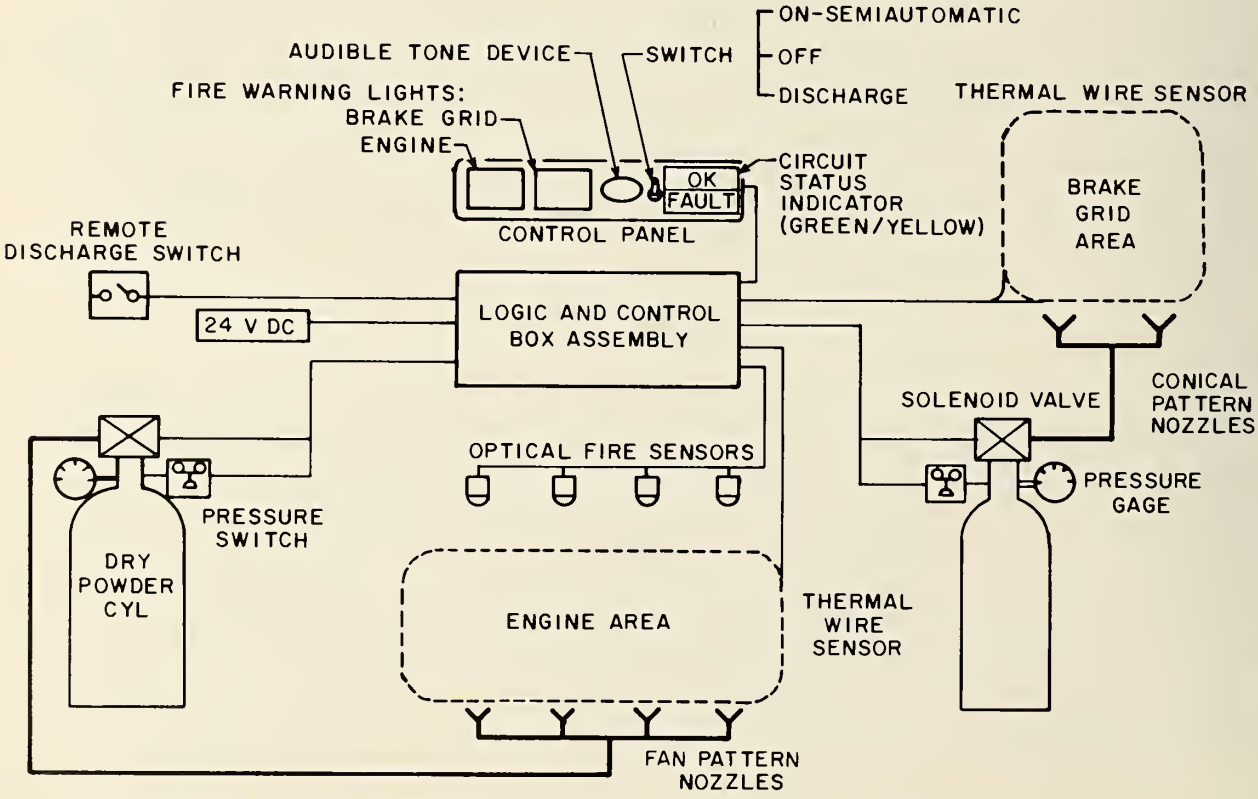


FIGURE 2. - Schematic of first fire protection system.

size considering the 200-ton-capacity models now available). Although the floor of the cab was only 8-1/2 feet above the ground, the driver fractured both heels and received first and second degree burns. The Bureau of Mines Health and Safety Report (No. 20-00424) concerning this accident stated: "An automatic fire extinguishing system [might] have prevented personnel injury and minimized property damage." Although the truck was equipped with a manually activated, fixed fire suppression system, the driver did not activate the manual system before he jumped.

To help solve this metal mining health and safety problem, and to better protect expensive equipment, the Bureau of Mines let two research and development contracts to FMC Corp. (FMC), San Jose, Calif., to develop improved fire protection prototype systems for large mining vehicles. The first contract, awarded in June 1972, was completed in May 1973; the second contract, awarded in June 1973, was completed in April 1974. This Bureau of Mines report discusses the fire protection systems developed under these contracts and illustrates their use.

DEVELOPMENT OF DESIGN CRITERIA AND PROTOTYPE DEMONSTRATION

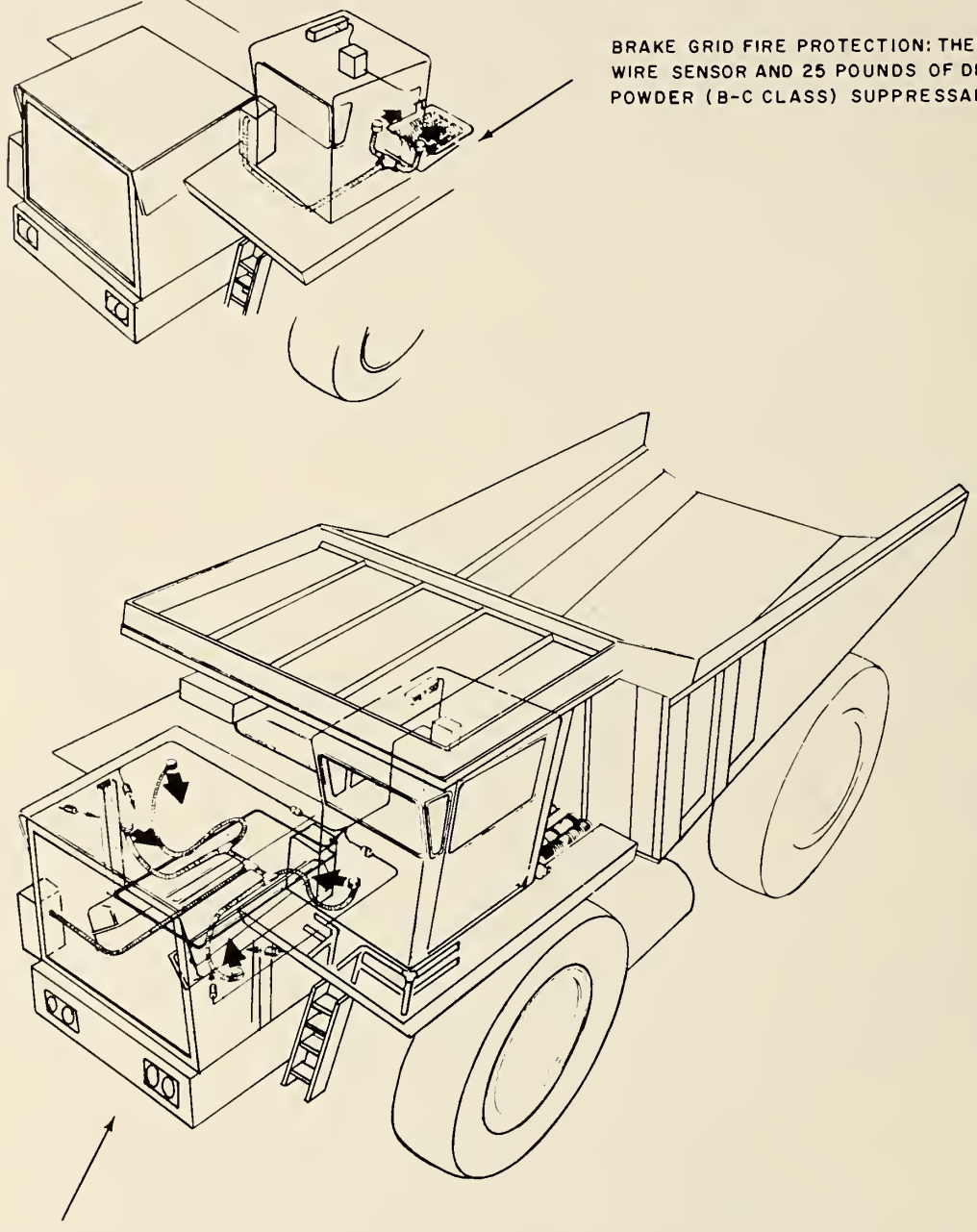
The objectives of the first contract were to identify the most fire-prone class of surface mining equipment and then design and test a reliable fire protection system that could be produced at a reasonable price to solve the problem. Manually activated, fixed (that is, permanently installed), dry chemical fire protection systems for trucks had been on the market for a few years, but many complaints from mine operators indicated that the systems currently available were inadequate for proper driver and truck protection.

FMC confirmed that haulage trucks of 100-ton capacity represented the greatest fire hazard and that most vehicle fires resulted from broken hydraulic lines. Design criteria were then generated for a "dual sensing, automatic with manual override, fire detection and suppression system." The recommended criteria incorporated both near-infrared and thermal wire sensors to detect fires. The design had electronic self-checking, fail-safe features, plus a timing sequence to allow the driver to test a suspect fire-warning signal and use his manual suppressant-dispersion switch if he believed the system was malfunctioning. This system was designed to protect the engine compartment and brake grid areas of a truck with pressurized, B-C class dry chemical. If the driver did not manually disperse the powder when he saw a fire, or if he was incapacitated, the system would automatically disperse the suppressant before the fire became too large to control. This "automatic, with manual override" system control feature is considered preferable to a manually activated system because of the frequent panic situation during a fire emergency. As happened in Michigan, a driver's first thought when a flash fire occurs is of getting away from the truck; thus, he may forget to initiate a manually activated type, fixed fire control system. Figure 1 depicts the typical factors considered in developing the first fire protection system. Figure 2 is a schematic of the first automatic truck fire protection system design.

The third and final objective of the first contract, prototype fabrication and in-mine, on-truck demonstration of the effectiveness of the system, was accomplished when the prototype (fig. 3) was successfully fire-tested during April 1973 on a 100-ton-capacity truck at the Pima mine, Tucson, Ariz. Fires set in the engine compartment and brake grids of the truck were sensed by the system and automatically extinguished. Mockup system component testing (fig. 4) preceded the Pima mine truck fire tests (figs. 5-7).

FIRST PROTOTYPE

SHOWN AS INSTALLED ON THE 100-TON-CAPACITY TEST TRUCK AT THE PIMA MINE, TUSCON, ARIZONA, IN MARCH 1973 (SYSTEM DEMONSTRATION) AND JULY TO NOVEMBER 1973 (LONG TERM, HOT WEATHER SYSTEM VALIDATION TEST)



BRAKE GRID FIRE PROTECTION: THERMAL WIRE SENSOR AND 25 POUNDS OF DRY POWDER (B-C CLASS) SUPPRESSANT

ENGINE AREA FIRE PROTECTION: BOTH OPTICAL AND THERMAL WIRE SENSORS AND 18 POUNDS OF DRY POWDER (B-C CLASS) SUPPRESSANT

FIGURE 3. - First prototype.

FIGURE 4. - Mockup testing.

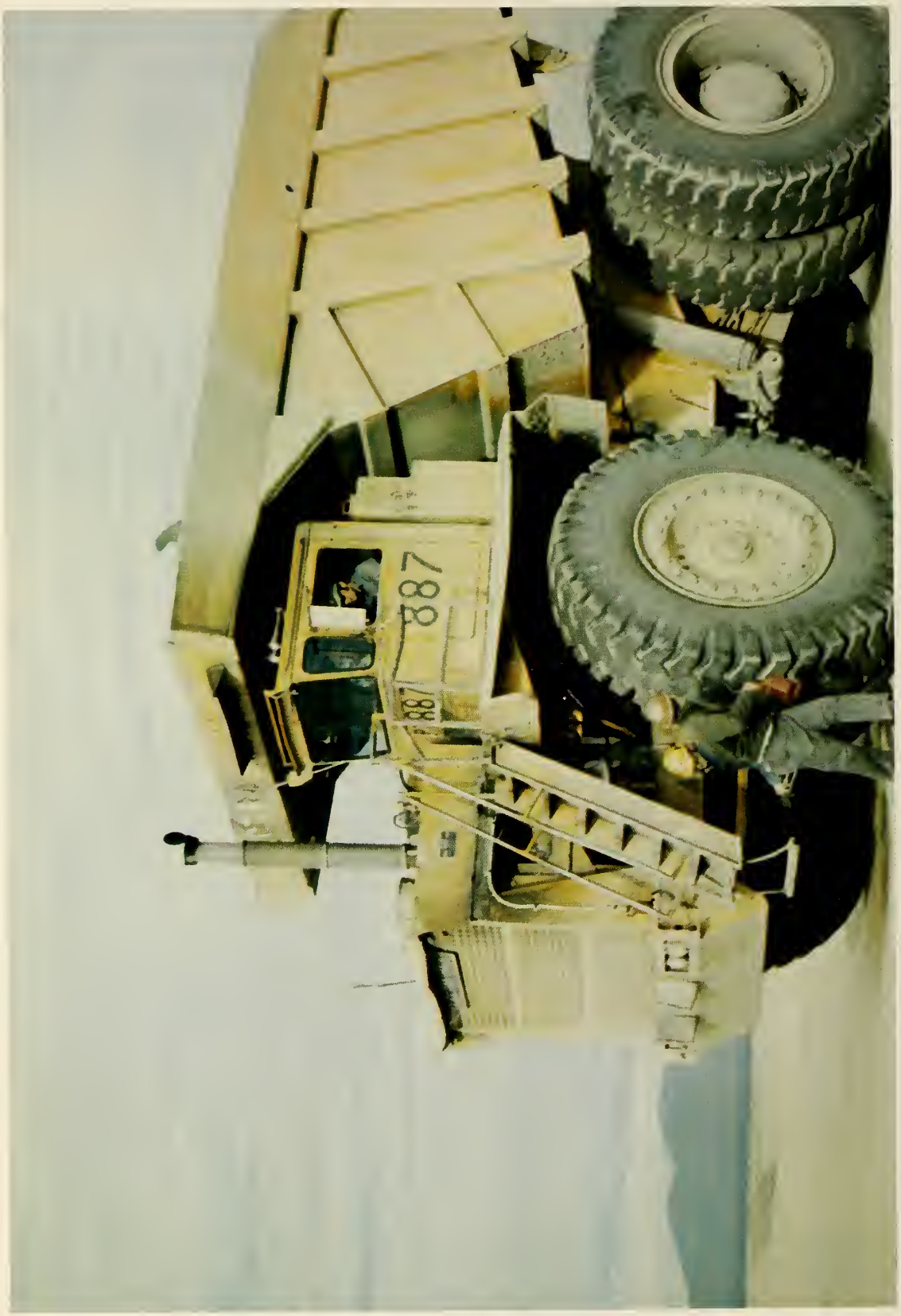


FIGURE 5. - Lighting the truck fire at Pima.

FIGURE 6. - Pima truck fire being automatically extinguished.

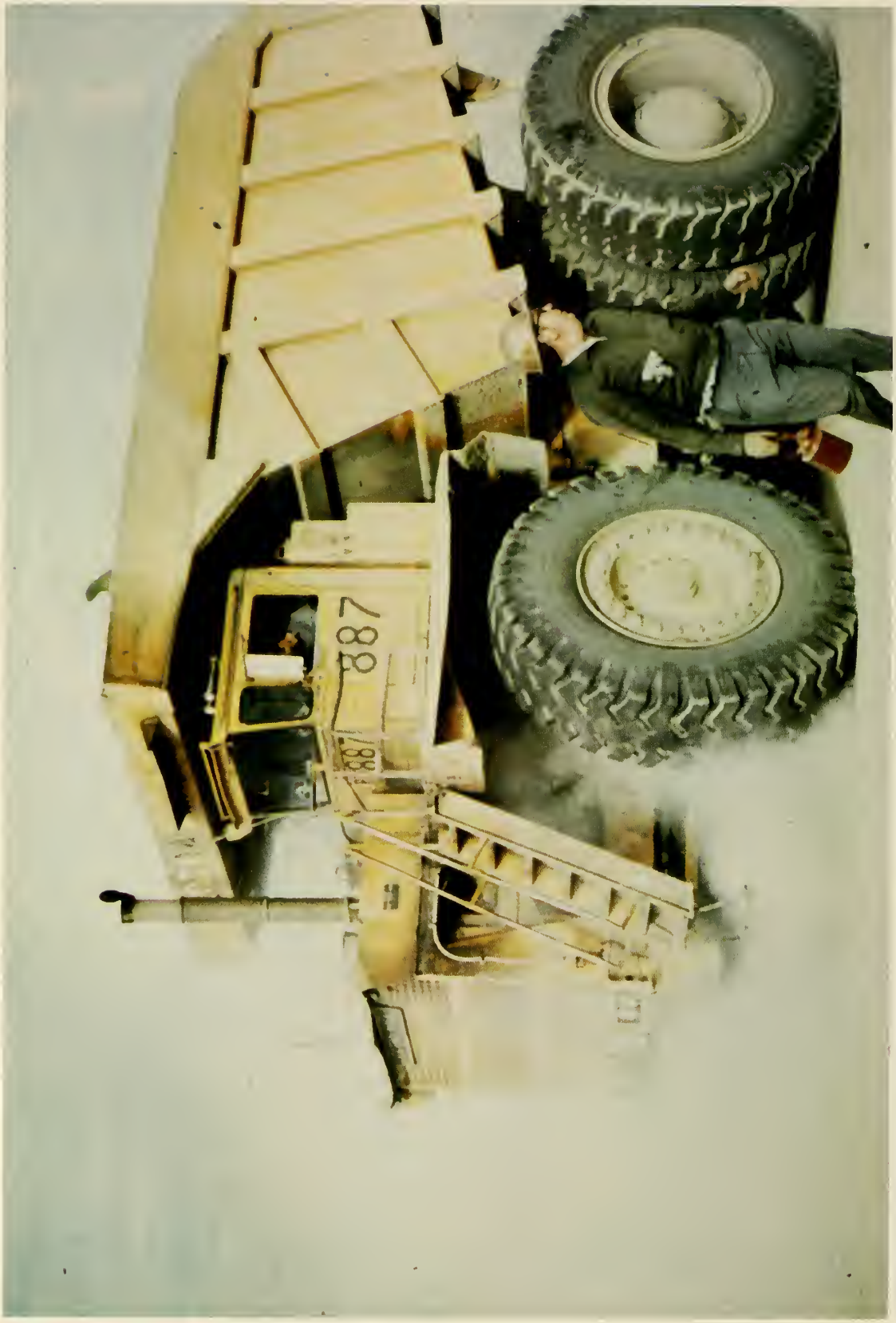
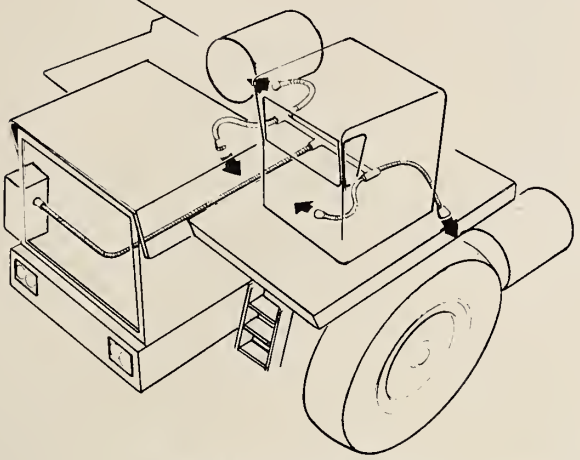


FIGURE 7. - Pima truck fire successfully extinguished.

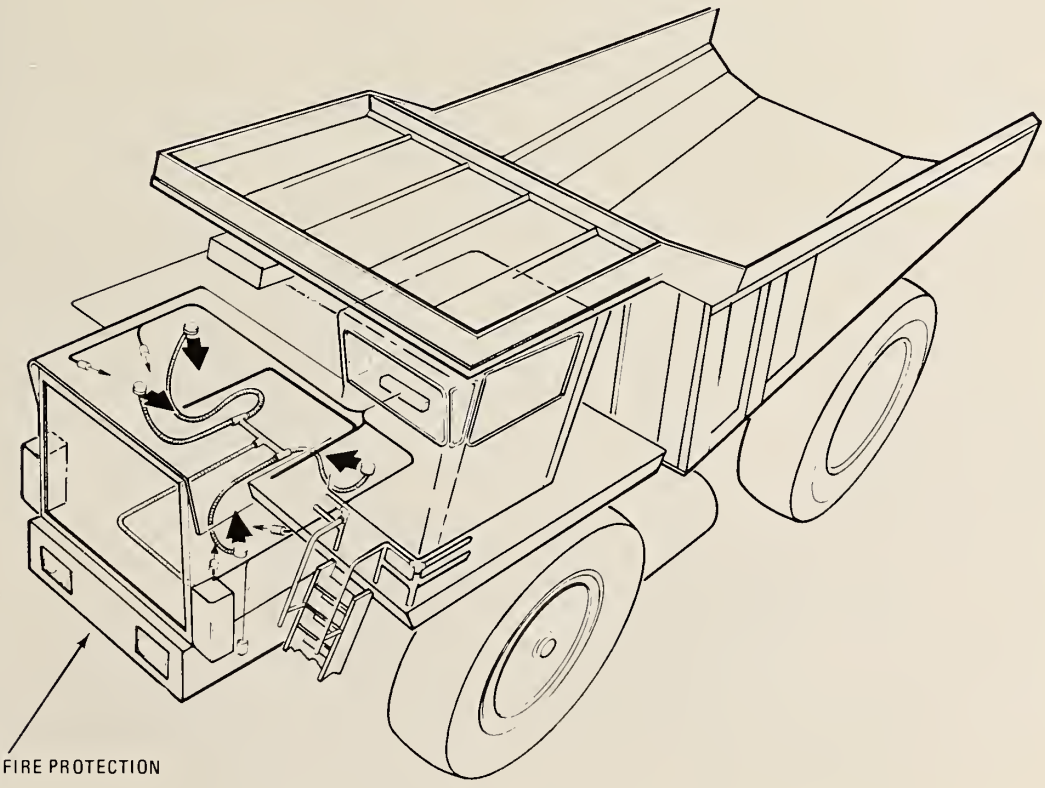
SECOND PROTOTYPE

SHOWN AS INSTALLED ON THE 100-TON-CAPACITY TEST TRUCK AT ERIE MINING COMPANY, HOYT LAKES MINNESOTA, FROM DECEMBER 1973 TO FEBRUARY 1974 (COLD WEATHER SYSTEM VALIDATION TEST)



FUEL-OIL TANK FIRE PROTECTION

DESIGN CHANGES FROM 1ST PROTOTYPE
- SIMPLIFIED CONTROL PANEL
- NO BRAKE GRID FIRE PROTECTION
- TEMPERATURE COMPENSATED THERMAL SENSOR
- ADDITIONAL TEST AND FAIL SAFE CIRCUITS



ENGINE AREA FIRE PROTECTION

FIGURE 8. - Second prototype.

ENDURANCE TESTING OF THE FIRST SYSTEM'S PROTOTYPE AND DEVELOPMENT, AND TESTING OF THE SECOND SYSTEM'S PROTOTYPE

To further develop fire protection systems, a second contract was negotiated with FMC to reinstall the first automatic truck fire protection prototype on a 100-ton-capacity truck at the Pima mine for a 4-month system reliability test. This hot weather endurance test took place during the summer of 1974. During the test period, an accidental flash fire occurred in the engine compartment of the test truck while it was working in the pit. A faulty oil filter seal sprayed oil on the hot engine. The driver did not manually discharge the system before he left the cab. However, the system automatically sensed and extinguished the fire with so little damage to the truck that the truck was back in service within 8 hours. Similar fires in the past have cost from $15,000 to over $40,000 in equipment repairs.

As a result of the experience gained during the testing at Pima, a second modified system was designed and fabricated. This second prototype was then subjected to 6 weeks of on-truck cold weather testing at the Erie Mining Co., Hoyt Lakes, Minn., in the winter of 1974. The modified system (1) protects the engine compartment and fuel tank area of a truck rather than the brake grid area, (2) includes an increase from one to two 25-pound-capacity dry chemical cylinders used in the truck's engine compartment and fuel tank area, and (3) changes the thermal detection subsystem to automatically compensate for changes in outside ambient air temperature, thereby making the modified system more sensitive to fire stimulus.

The second prototype (fig. 8) was successfully subjected to truck fire tests at Erie at the end of the on-truck, cold weather endurance testing. Figure 9 shows the components of the modified system. Figure 10 is a closeup of the second system's control panel as installed on the Erie truck. Figures 11 through 14 show the ignition, burning, and automatic suppression at one of the Erie test fires.

FIGURE 9. - Components of the modified system.

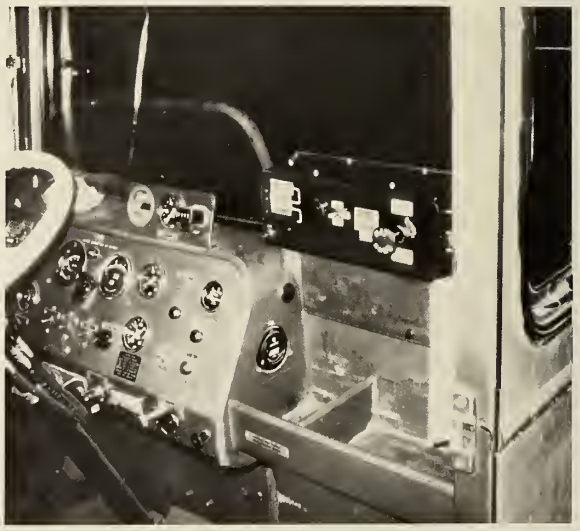


FIGURE 10. - Modified system's control box mounted in Erie truck.

FIGURE 11. - Lighting the truck fire at Erie.

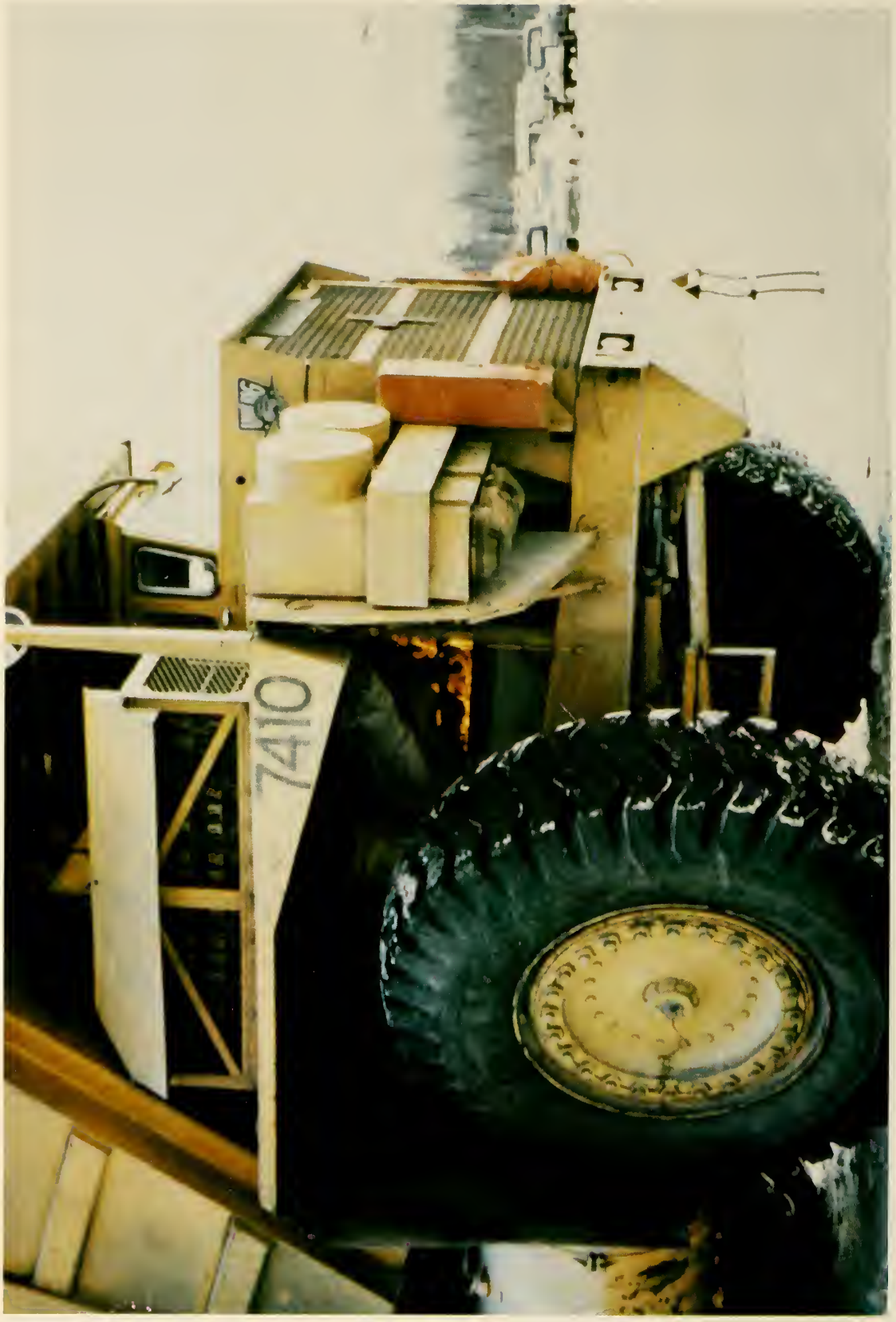


FIGURE 12. - Erie truck burning.

FIGURE 13. - Erie truck fire being automatically extinguished.

FIGURE 14. - Erie truck fire successfully extinguished.

Detailed information on the automatic truck fire protection systems can be acquired from three final reports of the Bureau of Mines and FMC Corp.[3] Both systems are easy to install and cost about $3,000 to $5,000, which is quite reasonable when compared with the $250,000 and higher cost of today's large ore haulage vehicles.

SUMMARY AND CONCLUSION

Mine haulage vehicles are becoming larger and thus more dangerous during a fire emergency. This is because of (1) the increased height of the cab above ground, (2) the location of the ladder, and (3) the driver's inability to see the fire in time to escape because of the position of the cab on the vehicle. To alleviate this safety problem and better protect expensive equipment, the Bureau of Mines, through two research and development contracts with the FMC Corp., San Jose, Calif., has developed automatic fire sensing and suppression systems for large haulage vehicles. Prototypes of the systems have been built and demonstrated in actual truck fire tests and long-term, in-mine endurance tests. The first system protects the engine compartment and fuel tank area, and has improved components. Both systems use optical and thermal sensors, automatic controls with manual override, and fixed fire extinguishers with pressurized, B-C class dry chemical. Both systems have control panels located in the cab and can be manually activated via switchs at ground level.

Automatic engine shutdown was not a feature of the prototype system, but such a design alternative could be easily added if a user desired such an option. Flexibility has been designed into the systems so that they can be installed, with modifications, in most large mobile mining equipment.

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[3]FMC Corporation. Improved Sensors and Fire Control Systems for Mining Equipment. Phase 2. Final Report. BuMines Open File Report 25(2)-74, May 1973, 178 pp.; available for consultation at the Bureau of Mines libraries in Pittsburgh, Pa.; Twin Cities, Minn.; Spokane, Wash.; and Denver, Colo.; and at the Central Library, U.S. Department of the Interior, Washington, D.C.; and from National Technical Information Service, Springfield, Va., PB 232 406/AS.

FMC Corporation. Truck Fire Protection System Validation. Final Report. System Modification and Validation Testing of Fire Protection Systems for Mine Haulage Trucks. BuMines Open File Report 33-74, April 1974, 170 pp.; available for consultation at the Bureau of Mines libraries in Denver, Colo.; Pittsburgh, Pa.; Spokane, Wash.; Morgantown, W. Va.; and Twin Cities, Minn.; and at the Central Library, U.S. Department of the Interior, Washington, D.C.; and from National Technical Information Service, Springfield, Va., PB 234 577/AS.

FMC Corporation. A Guide to the Selection of Automatic Fire Protection Systems for Mine Haulage Equipment. BuMines Open File Report 34-74, April 1974, 8 pp.; available for consultation at the Bureau of Mines libraries in Denver, Colo.; Pittsburgh, Pa.; Spokane, Wash.; Morgantown, W. Va.; and Twin Cities, Minn.; and at the Central Library, U.S. Department of the Interior, Washington, D.C.; and from National Technical Service, Springfield, Va., PB 234 575/AS.

The Bureau of Mines plans to continue development and to encourage the use of automatic vehicle fire protection systems through no-cost cooperative agreements with the FMC Corp., the Ansul Co. of Marinette, Wis., the Walter Kidde Co. of Belleville, N.J., the Lease-Martin AFEX Co. of Raleigh, N.C., and interested mining companies. System components (and variations thereof) are available from FMC, Ansul, Kidde, and AFEX and are currently being used on various pieces of mining equipment.

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